Silicon Consortium Project R&D – FY23

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EIC Silicon Consortium Meeting

29 August 2022

Introduction

- Restart this meeting on a bi-weekly schedule after a break in August, following the EIC User Group meeting,

- If there are concerns or constraints or simply inconveniences with the day or time – Mondays at 1pm U.S. Eastern Time – please reach out so that we can attempt to accommodate,

- Today is a Summer Bank Holiday in the U.K. We thus considered postponing, however, next week would be a Holiday in the U.S., and, well, time is precious.

- Must restart in view of a project R&D deadline of upcoming October 1, 2022. Nominally we will have three regular meetings to get this done, including this one,

- The *generic* R&D proposal may feel like yesterday, at least to some of us, but that is or was separate,
- Here, we are dealing with continuations of eRD104, eRD111, and a new sensor R&D proposal.

Some context from the EIC project,

- Rolf Ent / Elke Aschenauer updated the nascent collaboration during the general collaboration meeting last week, c.f. https://indico.bnl.gov/event/16020/, on the project:

From Jim Yeck's slides at recent EICUG Meeting

This becomes real now

CD-2/3A Planning Dates

• DOE OPA Status Review (Remote)	October 19-21, 2021(A)
• Funding Discussion at DOE ONP (In-Person)	April 26, 2022 (A)
• FPD Status Update at BNL (Hybrid)	June 28, 29, 30 2022
• Cost and Schedule Scrutiny Meetings	July - August 2022
• Project Detector Meetings	Fall 2022
• DOE OPA Status Review - Confirm CD-2/3A Plans	January 2023
• Preliminary Design and Director's Reviews	June 2023
• DOE CD 2/3A OPA Review and ICR	October 2023
• DOE CD 2/3A ESAAB Approval	January 2024

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- c.f. https://www.directives.doe.gov/terms_definitions/cd-2-approve-performance-baseline

Some context from the EIC project,

- Recall also from Elke Aschenauer / Rolf Ent's presentation during the EIC User Group meeting earlier this Summer, c.f. https://indico.bnl.gov/event/15342/

Timeline: What is Coming

CD-0 approval	December 19, 2019
Community-wide Yellow Report effort	Dec. 2019 – Feb. 2021
CD-1 review (includes CDR)	January 26-29, 2021
Call for Collaboration Proposals for Detectors	March 6, 2021
CD-1 approval	June 29, 2021
DOE/OPA Status Review	October 19-21, 2021
Status Update to Federal Project Director	June 28-30, 2022, @BNL
Technical Subsystem Reviews	January – December 2022
EICUG Meeting at SBU	July 2022
Detector-1 Collaboration Formation	Summer-Fall 2023
OPA Status Review	January 2023
Preliminary Design Complete & Review	May 2023
Final Design/Maturity Readiness for CD-3A Items	May 2023
CD-2/3A review (expectation), requires pre-TDR	~October 2023
CD-2/3A (expectation)	~January 2024
CD-3 review (expectation)	~January 2025
CD-3 (expectation), requires TDR	~April 2025

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Guidance on FY23 Project R&D

- Various timelines are obviously pressing; the proposal, R&D, and the upcoming pre-TDR,
- FY22 R&D is indeed only just now getting underway even though FY22 ends upcoming September 30. For continuations - eRD104 and eRD111 in our case - we will need to give careful consideration to what effort can be scaled up and how to meet the overall timelines. Progress reports are needed as part of the proposal.

- Milestones, timeline, and budget need to be described in detail – similar to what was done for FY22 (strongly suggest to develop preliminary statements-of-work simultaneously),
- Project R&D concentrates on tasks that mitigate project detector technical, cost, or schedule risk,
- Inclusive and (to) integrate interested parties in the community.

- eRD104 has thus far focused on powering and readout,
- eRD111 has thus far focused on forming modules from stitched sensors, stave and disc construction, additional infrastructure including mechanics and cooling,
- eRD113 will be new for FY23 and focuses on sensor R&D

Plan and goals this and next meetings

- Today, review current reference concept/design for the project detector for the MAPS-based tracking and vertexing subsystem(s),
- Discuss and explore areas of interest.
- September 12, ask that reports on progress written, interests be identified including resource needs and schedule - aim for an initial pass at areas of overlap and holes,
- September 26, finalize proposal for submission by October 1.
- Additional meetings with the group as a whole or in subgroups will be organized as needed,
- We have started separate overleaf documents for eRD104, eRD111, and eRD113 – please simply speak up now or reach out later to be added as an editor.

Transition from reference detector to baseline

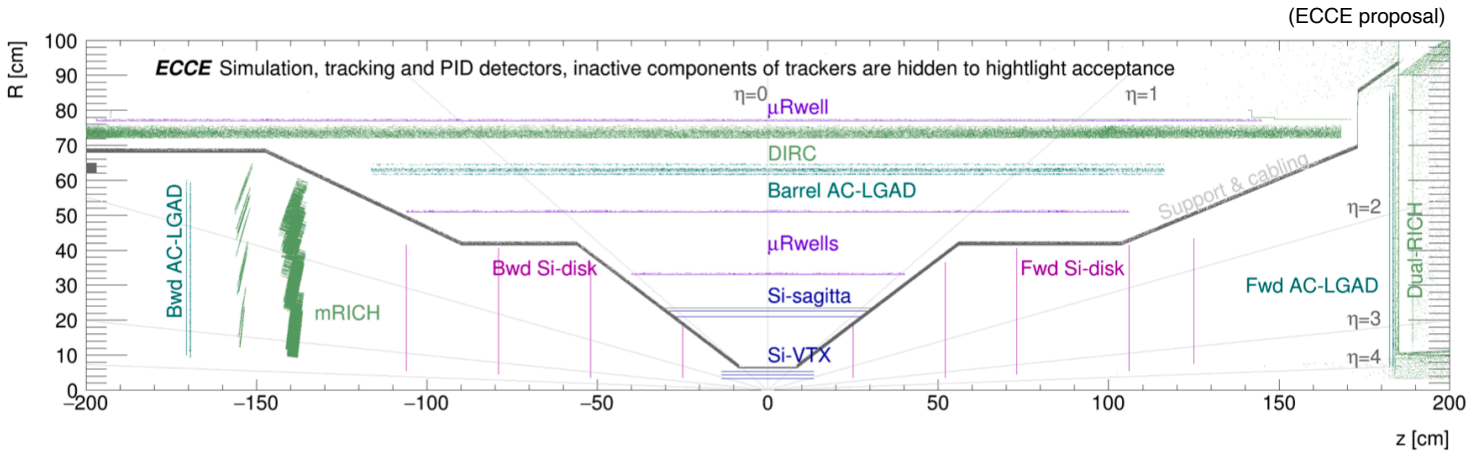


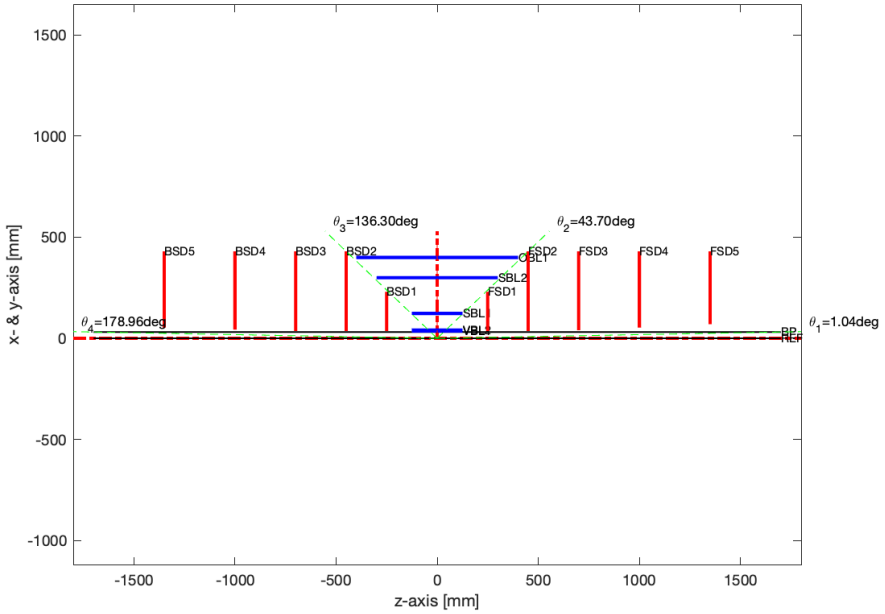
Figure 2.5: Schematic view of the ECCE tracker, including silicon, μRWELL, AC-LGAD, DIRC, mRICH and dRICH detector systems.

- Reference concept / design based on the ECCE proposal following DPAP,
- Since then, the magnet situation has improved bringing an increase in overall field to an overall ~1.7 T,
- The collaboration has made revisions to the barrel MAPS subsystem,
- Changes to the disks are also being implemented following changes to the barrel and considering basics aspects of tracking at high eta,
- Many aspects remain open, but significant steps forward have been made.

Current configuration (as of 25 August 2022)

Barrel:

	r [mm]	l [mm]	X/X0 %
Layer 1	36	270	0.05
Layer 2	48	270	0.05
Layer 3	120	270	0.05
Layer 4	270	540	0.25
Layer 5	420	840	0.55



Disks:

- Suggested |z| = 250, 450, 700, 1000, 1350* mm.
- r_{out} = 430mm** at |z| > 430mm, ~230 mm at |z| = 250mm
- X/X0 ~ 0.24% per disk
- r_{in} ~ 5mm away from beam pipe
- Outer support / service cylinders for 450 < |z| < 1350* mm

* z=1350 mm would put the last disk right against the mRICH in the e- direction; TBC pending checks with project engineers/up-to-date CAD drawing.

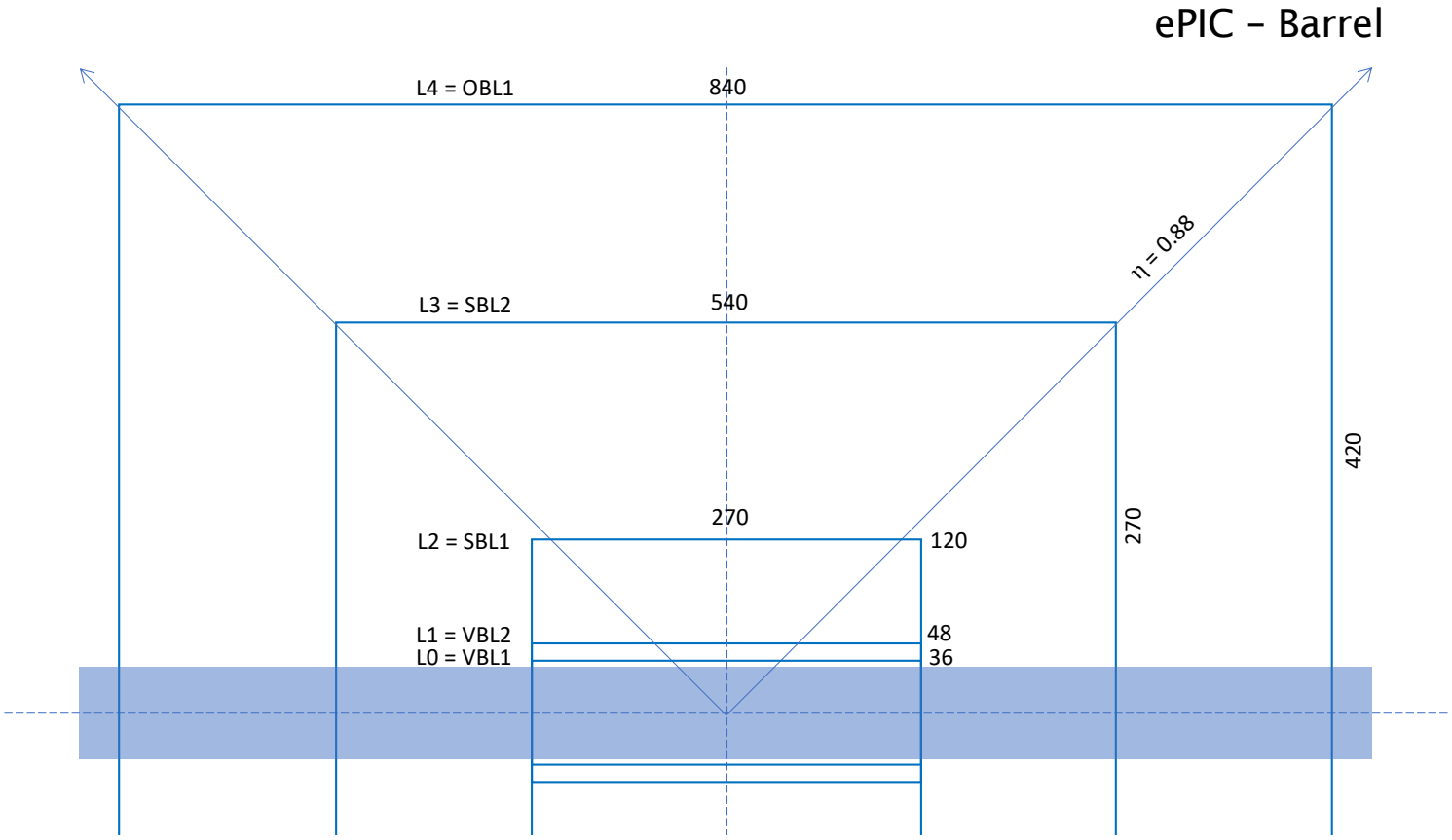
c.f. https://indico.bnl.gov/event/16582/

EIC Sensors – Vertex, Barrel & Disks

- EIC Vertex Layers
  - Use ITS3 curved wafer-scale sensors.
  - Now comprises 2 vertex layers and 1 (first) sagitta layer.
  - Radii = 36 mm, 48 mm and 120 mm.
  - Note beampipe outer radius = 31.75 mm.
- EIC Sagitta Layers
  - Use smaller format ITS3 sensor (i.e. stitched not wafer-scale) on staves → EIC Large Area Sensor (LAS)
  - Comprises 1 (second) sagitta layer and 1 (outer) barrel layer.
  - Radii = 270 mm and 420 mm.
- EIC Disks
  - Requires smaller format sensors for improved yield and tiling flexibility.
  - Multiple sensor formats needed – changes to stitching plan & periphery.
  - Studying optimum tiling geometry.

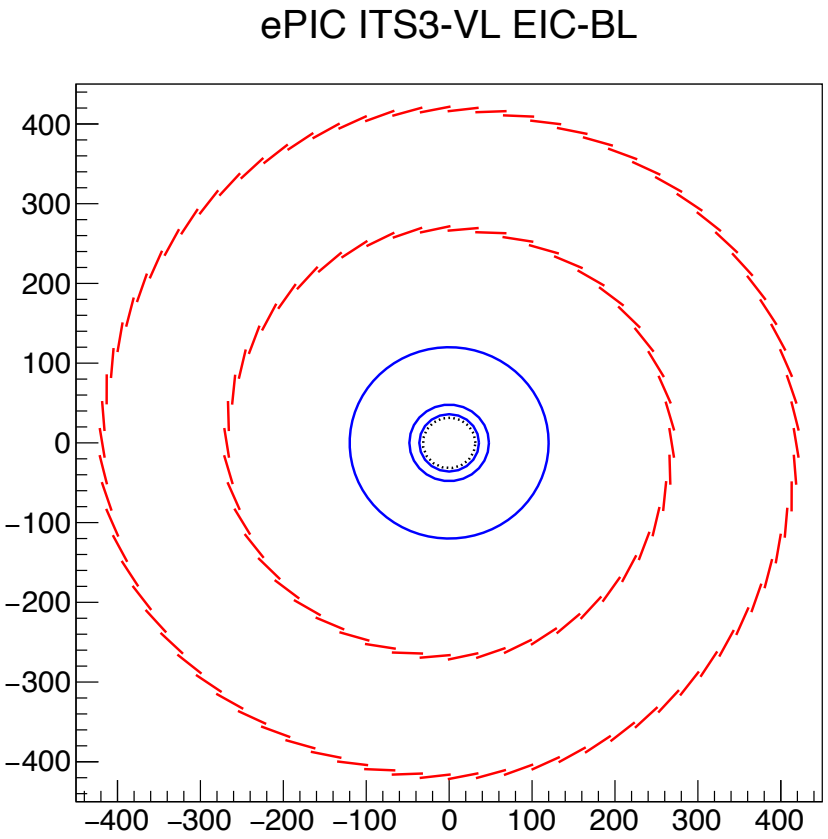
The following slides show part of an ongoing study by Peter Jones, who is not available for today's meeting but will update at an upcoming meeting.

Conceptual design of barrel layers



Note: radii and lengths work with a reticle size of 18.85 x 30.00 mm^2.
Length of L0, L1 and L2 is made of one 270 mm sensor: read out at ONE end.
Length of L3 is (or can be) made of two 270 mm sensors: read out at BOTH ends.
Length of L4 is (or can be) made of four 210 mm sensors: read out at BOTH ends + services along the staves to reach 2nd and 3rd sensor.

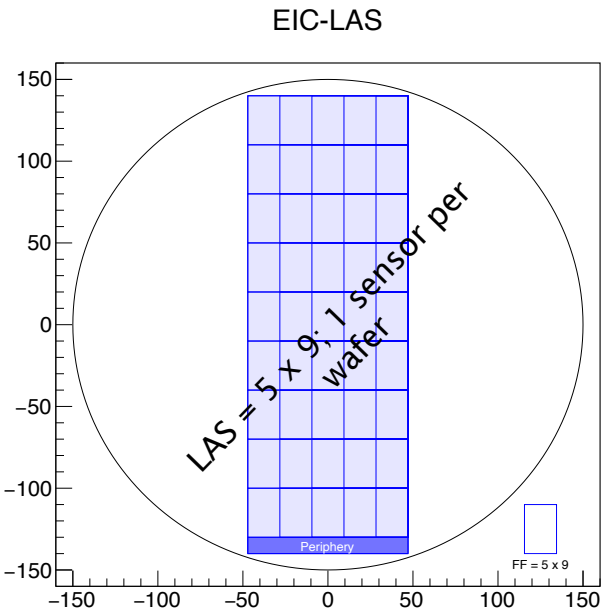
Conceptual design of barrel layers

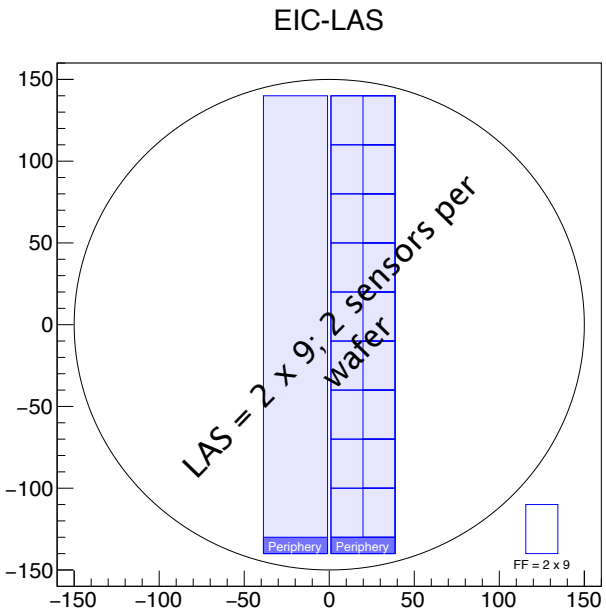


L3 = SBL2; R = 268.4 mm; LAS = 2 x 9; 100 sensors; rϕ olap = 3.5 mm
L4 = OBL2; R = 418.5 mm; LAS = 2 x 7; 312 sensors; rϕ olap = 3.5 mm
Overlap represents an increase in silicon area of 11%
Overlap of ALICE-ITS2 MBL and OBL staves is 4.3 mm

Example of implications on sensor design

L3 (r = 270 mm) as an example:



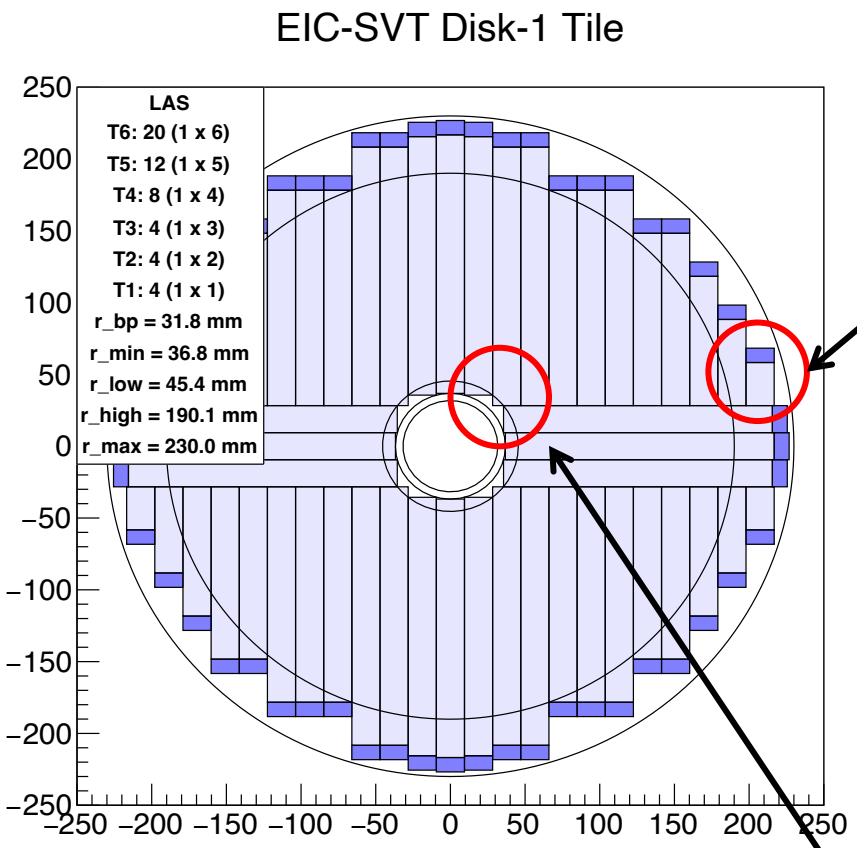


Note #1: more efficient use of silicon to make stave modules from two 1 x 9 sensors (5 per wafer) rather than 2 x 9 sensors (2 per wafer).

Note #2: Dependent on being able to have an independent periphery for each column.

Disk tiling studies

- Example: Disk 1



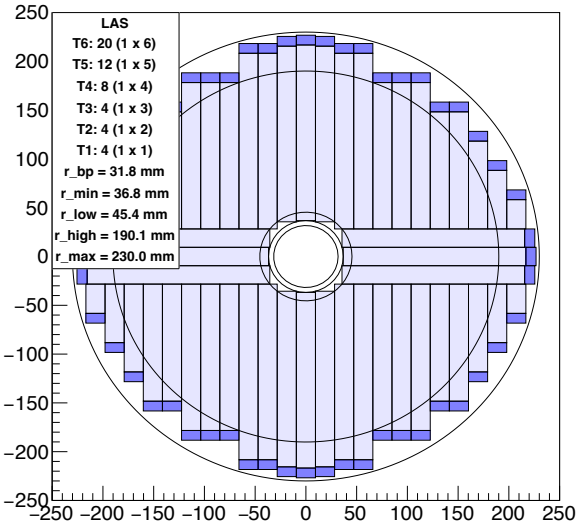
z = +/- 250 mm
Cruciform = 3 x 3 sensors

The algorithm

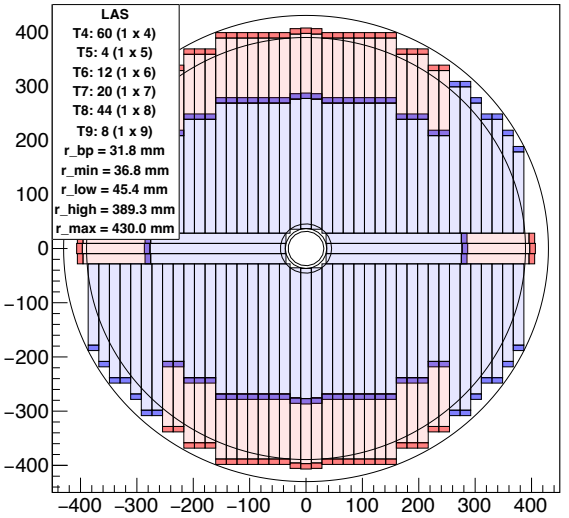
- Aim to keep periphery to larger radii
- Two designs, each based on a central cross pattern smaller than the inner diameter of the disk
- Design #1 = vertical tiles (shown)
- Design #2 = herringbone (alternating vertical and horizontal tiles)
- Limits on the max and min sensor length can be applied
- Study the number of sensor variants that are needed
- The minimum radius (r_min) is 5 mm larger than the beam pipe (r_bp) for bake out purposes
- Sensor and periphery must be contained within the min and max radii of the disk (r_min and r_max).
- For each disk, the algorithm calculates the smallest and largest radii with full acceptance (r_low and r_high)
- The algorithm does not permit any sensor overlap
- Acceptance at small radii could be improved by allowing some sensor overlap; placing overlapping sensors on the reverse side of the disk (in progress)

Some configurations under study as an example

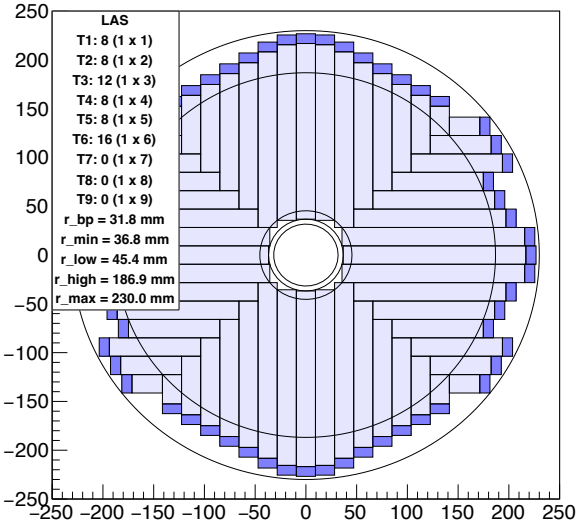
EIC-SVT Disk-1 Tile



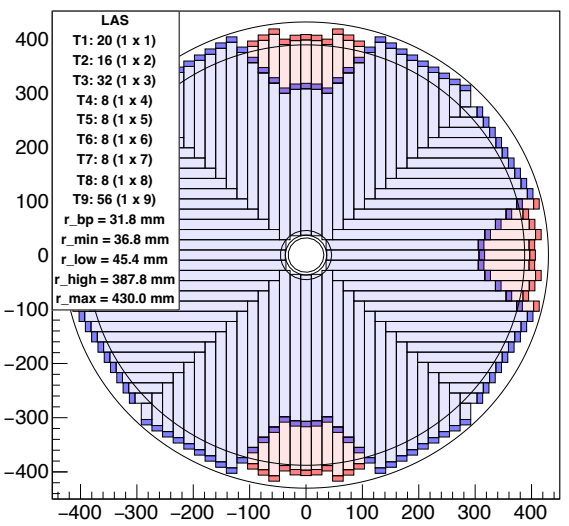
EIC-SVT Disk-2/3n Tile



EIC-SVT Disk-1 Tile



EIC-SVT Disk-2/3n Tile



Comments on ongoing disk tiling study

- Multiple sensor formats needed – requiring changes to stitching plan & organisation of the digital periphery,
- Attempt to minimise the number of formats by restricting the maximum and/or minimum sensor length,
- We have, indeed, moved away from earlier considerations of iris-like layout concepts towards a central cross-pattern to accommodate the (various) beam openings,
- Physics simulations to inform acceptance needs at small radii,
- Mechanical and material budget considerations to inform if disks can be stave-like or require monolithic disk halves,
- Power dissipation of the peripheries, in particular, to inform the need for any liquid cooling.

Our asks to you

- Please simply speak up now or reach out soon to be added as an editor for the separate overleaf documents for eRD104, eRD111, and eRD113 as appropriate,

- Prepare to present R&D progress by our meeting on September 12 and summarize this progress in the relevant eRD overleaf document – we are after basic entries; a Hemmingway or Pulitzer, although welcome, is not needed,

- On the same timeline, but preferably earlier by September 5, indicate in the relevant eRD overleaf document where you / your institution can contribute to FY23 project R&D, including timelines and resource needs,

- Please do not hesitate to reach out if the bifurcations just become too many and with any comments, requests, or questions.